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ROAD TRAFFIC INJURIES IN THE CONTEXT OF RAPID MOTORIZATION

Studies on access, provision and utilization of trauma care in Iran

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ABSTRACT

Background: Iran has one of the highest traffic-related mortality and morbidity rates in the world. Evidence shows that improvements in trauma care can prevent a substantial number of road traffic deaths and disabilities.

Aim: The overall aim of this thesis is to explore factors influencing access, provision and utilization of trauma care for road traffic injuries (RTIs) in Iran.

Methods: The thesis is based on four studies. Study I is a national ecological study in order to assess if the *distribution of pre-hospital trauma care resources* reflects the needs in terms of traffic-related mortality and morbidity in different provinces in Iran. Inequality measures and correlation analysis were used in the analysis. In Study II, qualitative interviews were conducted with 15 health professionals to explore factors influencing the *provision of pre-hospital trauma care* for RTI victims. In Study III, qualitative interviews were conducted with 15 health professionals and 20 RTI victims to explore factors influencing an effective trauma care delivery at *emergency departments (EDs)*. The grounded theory approach was used in both Study II and III. Study IV utilized the Iranian National Trauma Registry Database to assess *hospital resource utilization* (hospital charges and length of stay (LOS)) associated with RTIs in Iran and also to evaluate the association with the patients' socio-demographic characteristics, insurance status and injury-related factors. Univariable and multivariable analysis were used in this study.

Findings: There was no significant association between traffic-related mortality and morbidity and pre-hospital trauma care resources (I). Seven main factors that could hinder or facilitate an effective pre-hospital trauma care process were identified: administration and organization; staff qualifications and competences; availability and distribution of resources; communication and transportation; involved organizations; laypeople; and infrastructure (II). Lack of a systematic approach to providing trauma care at EDs emerged as the core category in Study III. Unclear national policies and poor organization of care at the ED were perceived as the main factors contributed to non-systematic approach but the contextual factors in the hospitals and those specific to the context of Iran also played a role. The mean (SD) total hospital charges and LOS for the patients were US$ 165 (US$ 290) and 6.8 days (8), respectively. Older age, being female, lower level of education, higher injury severity and longer LOS were associated with higher hospital charges. Longer LOS was associated with being male, lower education, having a medical insurance, being a farmer or a blue-collar worker and having more severe injuries (IV).

Conclusion: Pre-hospital trauma care resources across the country were not distributed based on needs in terms of traffic-related mortality and morbidity. For the provision of trauma care, the studies identified that there is a lack of interaction and common understanding among different actors involved in the pre-hospital trauma care and a non-systematic approach as the main barrier to managing trauma patients in the EDs. The findings indicated that the hospital resource utilization associated with RTI victims is substantial and varied based on the victims' socio-demographic characteristics, insurance status and injury-related factors. Both the pre-hospital and hospital organization, and interaction between them, need to be considered in order to reduce the high burden of RTIs in Iran.

Key words: Pre-hospital trauma care, emergency department, road traffic injuries, trauma care access, grounded theory, hospital resource utilization, low and middle-income countries

LIST OF PUBLICATIONS

I. Bidgoli HH, Bogg L, Hasselberg M. Pre-hospital trauma care resources for road traffic injuries in a middle-income country—A province based study on need and access in Iran. Injury 2011 Sep;42(9):879-84.

II. Haghparast-Bidgoli H, Hasselberg M, Khankeh H, Khorasani-Zavareh D, Johansson E. Barriers and facilitators to provide effective pre-hospital trauma care for road traffic injury victims in Iran: a grounded theory approach. BMC Emergency Medicine 2010, 10:20

III. Haghparast-Bidgoli H, Khankeh H, Yarmohammadian MH, Johansson E, Hasselberg M. Exploring the provision of hospital trauma care for road traffic injury victims in Iran: a qualitative approach. Submitted

IV. Haghparast-Bidgoli H, Saadat S, Bogg L, Yarmohammadian MH, Hasselberg M. Factors affecting hospital resource utilization associated with road traffic-related injuries in Iran. Submitted

CONTENTS

LIST OF ABBREVIATIONS

RTC	Road traffic crash
RTIs	Road traffic injuries
WHO	World Health Organization
DALYs	Disability Adjusted Life Years
LMICs	Low and middle-income countries
HICs	High income countries
GNP	Gross National Product
ED	Emergency department
EMS	Emergency Medical Services
MOHME	Ministry Of Health and Medical Education
INTRD	Iranian National Trauma Registry Database
EMT	Emergency Medical Technician
YLL	Years of Life Lost
BLS	Basic Life Support
ALS	Advance Life Support
GPS	Global Positioning System (Satellite Navigation system)
FMO	Forensic Medicine Organization
SCI	Statistical Center of Iran
ICD-10	International Classification of Diseases, 10^{th} revision
GCS	Glasgow Coma Scale
ISS	Injury Severity Score
LOS	Length of stay
EMP	Emergency Medicine Physicians
PHTLS	Pre-hospital Trauma Life Support

1 BACKGROUND

1.1 GLOBAL BURDEN OF ROAD TRAFFIC INJURIES

Injuries, which are considered largely preventable, are a leading cause of death and disability worldwide [1, 2]. Every year, 5.8 million people die from injury, and many more are disabled [1, 2]. Road traffic crashes (RTCs) account for about 25% of all fatal injuries in the world and 22% of injury-related Disability Adjusted Life Years (DALYs) [3]. According to the World Health Organization (WHO), each year over 1.2 million people die in the world due to RTCs, and between 20 and 50 million suffer non-fatal injuries [3, 4]. It is estimated (conservatively) that, in total, between the first fatal RTC in 1896 (a pedestrian in London hit at 4 mph), and the end of 1997, 25 million people have lost their lives in RTCs [3, 5]. According to WHO, globally, an average of 3,242 people lose their lives due to road traffic injury (RTI) every day [3]. It is estimated that RTI deaths will rise to the fifth leading cause of death by 2030 resulting in an estimated 2.4 million deaths per year, unless preventive efforts are undertaken [4].

Low and middle-income countries (LMICs) account for 90% of DALYs lost and for 90% of the deaths from RTC [3, 4, 6]. Over 50% of deaths occur among young adults in the age range of 15–44 years [3], consequently are a leading cause of premature loss of productive life, high medical care costs, significant degrees of disability and large socio-economic loss to society [7]. RTIs are one of the major causes of hospital admissions, especially in LMICs. In a review of 15 studies in LMICs, between 30 and 86% of trauma admissions were due to RTCs [5, 8]. RTIs are responsible for economic losses of approximately 1–2% of the annual gross national product (GNP) in different countries [3].

1.2 RISK FACTORS FOR ROAD TRAFFIC INJURIES

There are a variety of risk factors for RTIs, which have been discussed broadly in the literature. According to WHO[3], the main risk factors can be categorized into four groups: (1) factors influencing exposure to risk (e.g. social deprivation, age and sex), (2) risk factors influencing crash involvement (e.g. young male, fatigue, inadequate visibility), (3) factors influencing crash severity (e.g. not wearing safety equipment, excessive speed, alcohol) and (4) severity of injuries after RTC (e.g. delay in detecting crash and transportation to a health facility, inappropriate pre-hospital and hospital trauma care).

LMICs in general are experiencing a rapid urbanisation and motorisation, resulting in an increased exposure to risk factors for RTIs, such as unsafe public transportation, higher speed, and a diverse vehicle mix on the roads [9]. In addition, an inadequate public health infrastructure and unequal

access to trauma care in LMICs are considered to have an important role in the high burden of death and disability from RTIs in these countries [9, 10].

1.3 PROVISION OF TRAUMA CARE FOR ROAD TRAFFIC INJURIES (POST-CRASH CARE)

In order to minimize the burden of injuries, especially RTIs, a range of actions, including better surveillance and research, increased implementation of road safety and other forms of injury prevention, as well as strengthening of the current system of trauma care is required [2]. Many High Income Countries (HICs), but very few LMICs, have significantly reduced deaths and disabilities caused by injuries, particularly RTIs, mainly by improving the organization of trauma care [1, 2, 11].

The aim of trauma care for RTIs is, on the one hand, to avoid preventable death and reduce the severity of the injury and, on the other, to ensure best possible recovery of the crash survivor and re-integration into the community [12]. Trauma care for RTI includes a continuum of care and starts from the time of crash occurrence to the return of the injured person to an active life within society. Three components of trauma care are pre-hospital trauma care, care in hospital and rehabilitation [3, 12]. Figure 1 presents some of the main issues in trauma care discussed by the WHO [3, 12], the World Bank [13] and researchers within the area [7]. Reducing mortality and disability from RTIs requires an integrated approach with effective initial assessment and treatment at the scene of the crash, followed by efficient transport to hospital, and high quality care in emergency department (ED), surgery and intensive care units. Rehabilitation of the injured patient is similarly essential in order to reduce levels of post-trauma disability [7]. The current study focuses only on pre-hospital and hospital components of trauma care.

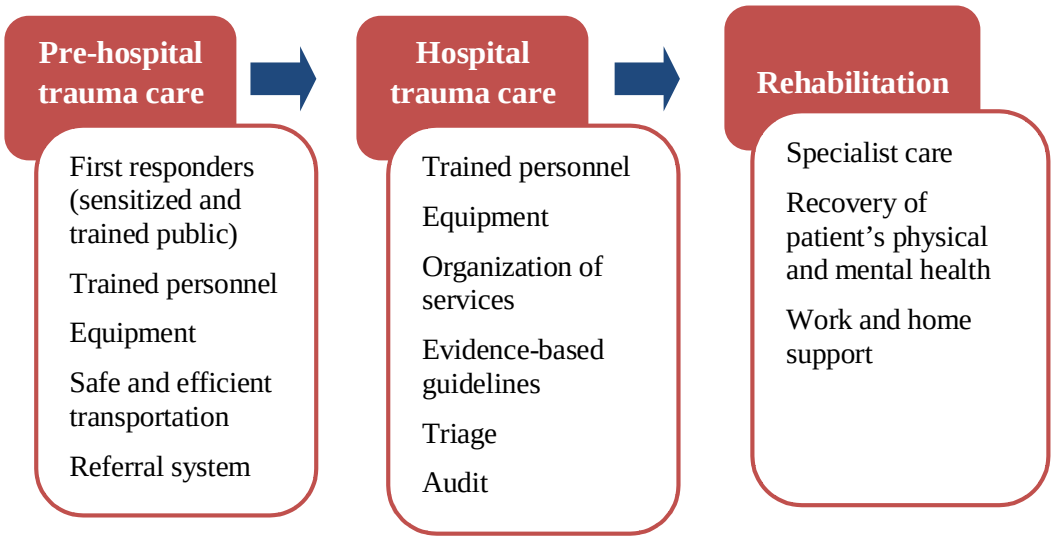

Figure 1: Elements of an effective post-crash care system **(**Adapted and modified based on sources [3, 7, 13])

1.3.1 Pre-hospital trauma care

Pre-hospital trauma care encompasses the care provided from the community (scene of injury, home, school, or other locations) until the patient arrives at a formal healthcare facility capable of giving definitive care. Pre-hospital trauma care should include basic and effective strategies and the most appropriate staff, equipment, and supplies needed to assess, prioritize, and institute interventions to minimize the probability of death or disability [13, 14].

Figure 2 shows a typical post-crash chain of events from the crash scene to a healthcare facility, which is common in countries with a basic formal pre-hospital system provided by the Emergency Medical Services (EMS). According to WHO, the essential elements of a pre-hospital trauma care system (regardless of how simple or sophisticated it is) should include prompt communication and activation of the system, timely response of the system, correct assessment and efficient treatment, and prompt transport of injured people to a formal health-care facility when necessary [12]. Generally, EMS is responsible for providing pre-hospital trauma care in many countries which acts as the link between pre-hospital care and care at the hospital.

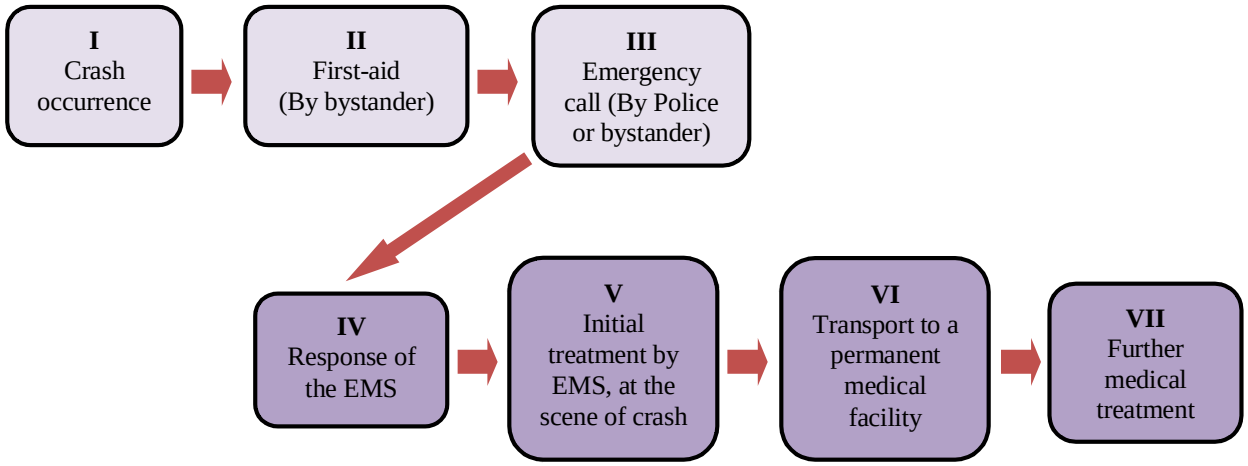

Figure 2: Chain of post-crash care events from the crash scene to the hospital (Reproduced with some modification from source [15])

1.3.1.1 Different levels of pre-hospital trauma care

Most pre-hospital care systems are comprised of providers with one or more of the following levels of training and skill:

First responders

In many communities, the first level of pre-hospital trauma care comprises of laypeople (known as first responders) who have been taught basic (and in some cases, advanced) first-aid skills. These people are mainly motivated laypeople or people from specific occupational groups (such as drivers of public transportation) who are trained to recognize an emergency, call for help and provide basic first-aid until more formally trained rescuers arrive [13, 16].

Basic pre-hospital trauma care

The second level comprises those people who have formal training in trauma care, usually Basic Life Support (BLS) skills. These individuals, who are usually called emergency medical technicians (EMTs), use dedicated vehicles and equipment for treatment and transportation of the victims to hospital [13, 16]. Many countries with established EMS and trauma care systems have a core group of these providers [16].

Advanced pre-hospital trauma care

Although many effective pre-hospital care systems in the world are limited to one or both of the first two levels of pre-hospital care, urban and suburban areas of many high-income and middle-

income countries provide a third level of care known as advanced pre-hospital care [13, 16]. The individuals who provide advanced pre-hospital care are mostly physicians or highly skilled non-physician paramedics. These individuals are trained in Advance Life Support (ALS) skills and can provide a wide range of invasive interventions [16]. In many countries, some ALS procedures (such as intravenous access and intubation) may be performed by specially trained providers of basic pre-hospital care [16].

1.3.2 Hospital trauma care

Capabilities of health care facilities and hospitals vary substantially between and within countries. **Human resources** (including staffing and training), **physical resources** (including infrastructure, equipment and supplies) and **organization of trauma care** are the key components of hospital trauma care which are discussed in the literature [1, 3, 17]. HICs have substantially decreased deaths and disabilities caused by injuries by improvements in the organization of trauma care (e.g. establishing trauma centers, founding organized trauma teams, implementing quality improvement programs) [1, 2].

1.3.3 Rehabilitation

Rehabilitation services are an integral part of the trauma care chain [7, 12]. Rehabilitation services help to minimize future functional disabilities and to restore the injured person to an active life within the community [12]. These services involve professionals from a range of disciplines in order to help the injured patients to recover both physically and mentally and regain their independence and reintegrate into daily life [12]. Many LMICs lack rehabilitation services [18], and if they exist, they are usually not an integrated part of trauma care system [19].

1.3.4 Three phases of deaths from severe injuries

Temporal and spatial distribution of trauma deaths has a substantial value for injury control programs and also a useful method to evaluate the quality of trauma care [20, 21]. This information provide useful tools for public health advocates and policy makers in order to allocate the limited injury control resources among prevention activities and pre-hospital and hospital trauma care improvement programs more efficiently [16, 21]. Deaths caused by severe injuries often occur in one of the following three phases (or follow a trimodal distribution) [16, 21] (Figure 3):

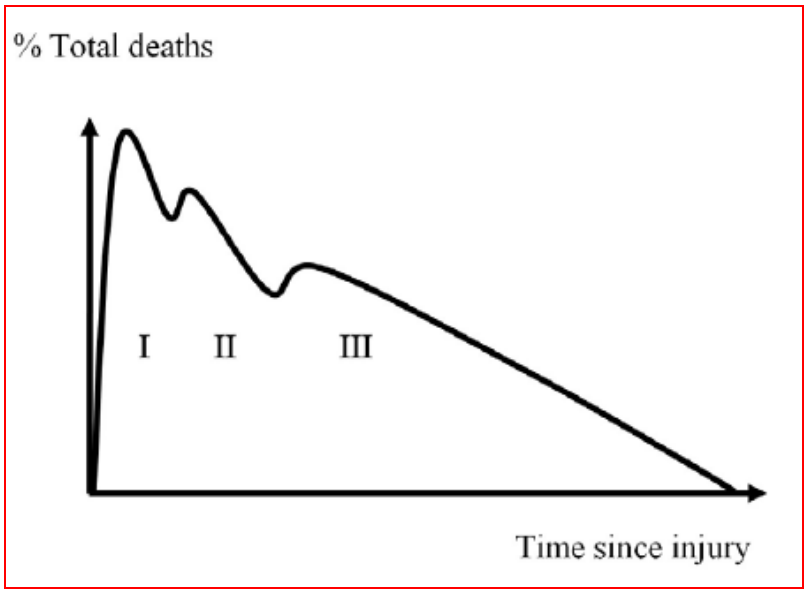

Figure 3: Trimodal distribution of fatal RTIs (Source [16])

In Phase I, death occurs immediately or quickly as a result of overwhelming injury. Due to the severity of injury, deaths occurring in this phase cannot be directly prevented by improving the quality of pre-hospital and hospital-based trauma care, however an organized system of care may support injury prevention efforts by providing information (such as identifying high risk groups, settings or behaviours) that may be useful for implementing prevention programmes [16, 21].

Phase II, includes fatalities that occur during the intermediate or sub-acute phase. These deaths, which usually occur within several hours of the crash, are often the result of treatable conditions such as airway compromise, respiratory failure or uncontrolled haemorrhage which can be readily treated using basic first aid measures. These injuries are often less severe and leave more time for pre-hospital and hospital trauma care providers to intervene and improve patients' outcome [16].

Deaths in **Phase III**, occur days or weeks after injury and are the result of complications of trauma. These fatalities often occur in a hospital. Therefore, the quality of trauma care that patients receive in ED and inpatient wards in hospital has a substantial impact on their outcome [16, 21]. Moreover, prompt and effective pre-hospital care can reduce the complications of the patients and prevent mortality [16].

A review of European studies on RTI deaths reported that about 50% of deaths from RTC occurred within minutes, either at the scene or while in transit to hospital. For those patients taken to hospital, around 15% of deaths occurred within 1-4 hours after the crash, but around 35%, occurred after four hours [3, 22, 23] In another study by Mock et al [24], comparing mortality among seriously injured patients in three countries with different development status, they found

that in all three settings, pre-hospital was the predominant place of death occurrence, ranging from 59% to 81% of deaths. However, the study showed that the probability of dying increased with lower socioeconomic level. Epidemiological studies measuring outcome of RTIs in Iran have shown that about 60% of the deaths occurred at the crash scene or on the way to hospital and more than 30 % at the hospital [25-27].

Considering this fact that the majority of trauma deaths in LMICs occur in the pre-hospital setting [17, 24, 26], it is suggested that improvements in pre-hospital trauma care would be more likely to decrease crash-related mortality and morbidity in these settings than would hospital-based trauma care [7, 16, 17, 28-31]. The major benefits of pre-hospital trauma care are realized during the second phase of trauma (within several hours of the crash), when the timely provision of care can minimize or prevent the cascade of events that otherwise quickly leads to death or lifelong disability [16].

1.3.5 Trauma care in LMICs

1.3.5.1 Access to trauma care

Pre-hospital trauma care: Studies have shown that many LMICs have insufficient pre-hospital trauma care [3, 32]. In these countries, few victims receive treatment at the crash scene and even fewer receive safe transport to the hospital by an ambulance. Injured people are usually cared for and transported to the hospital by relatives, untrained laypeople or drivers of commercial vehicles [3, 14, 16, 31, 32]. For example, a study in Kenya showed that the police and hospital ambulances provided transport for only 5.5% and 2.9%, of the crash victims, respectively [10]. Low usage of pre-hospital trauma care by trauma patients has also been reported in several studies in Iran [33-35]. For example, a survey in 2002 showed that only 14 per cent of injured people were transported to hospitals by ambulances and only 10 per cent received pre-hospital care by trained personnel [25].

Hospital trauma care: Shortage of trained staff and essential equipment and supplies in hospitals has been reported in several studies in LMICs [1, 3]. For example, in Ghana a study of 11 rural hospitals that received large numbers of RTI victims showed that all these hospitals were staffed mainly by general practitioners without trauma training [36]. These hospitals also lack essential low-cost equipment. For example, no hospital had chest tubes and only four had emergency airway equipment [36]. In another study in Kenya, only 40% of the health facilities – both outpatient and inpatient services – were reported to be well prepared and have key supplies available [10].

1.3.5.2 Utilization of trauma care

Studies on utilization of trauma care in LMICs are rare. In general, many victims in LMICs don't have health insurance and this limits access to and use of hospital care [10]. Patients in lower socio-economic groups also have poor access to hospital care [10]. In LMICs, vulnerable road users, including pedestrians, cyclists and motorcyclists mainly belong to lower socio-economic groups [10]. In a study carried out in Ghana, overall hospital use was found to be very low, where only 27% of all injured people used hospital services. Among patients with severe injuries, only 60% of victims in towns and 38% of rural victims received hospital care [3, 36].

1.4 BURDEN OF INJURIES AND ROAD TRAFFIC INJURIES IN IRAN

Iran faces one of the highest burdens of injuries throughout the world [19, 37]. Injuries are the first cause of years of life lost (YLL) among all causes of death in Iran (with 28% of YLL) [19, 37]. In addition, RTIs constitute the leading burden of disease in the country, with the highest number of DALYs accrued for the population [25, 38].

With the growing pattern of urbanization and motorization during the past few years, there has been a rapid increase in traffic-related injury mortality and morbidity in Iran [39] (Figure 4) which has made Iran a country with one of the highest RTI death rates in the world [40-42]. The RTI rate increased from 109.7 to 400.6 per 100 000 population between 1997 and 2005. Since 2005, due to national recognition of this problem and concerted interventions (particularly by the police), the traffic-related mortality rate has started to decrease [19], although injury rate, after a short downfall, has started to increase. In Iran, for each 100 road traffic crashes, four people die and the rate of death for every 10,000 vehicles is about 17.4 [19].

As traffic-related mortality and morbidity in Iran occur most commonly among young adults, the impact of RTIs is huge both in terms of human suffering and economic consequences for families and for the society [25, 40]. The annual cost of road traffic crashes in Iran is estimated to be approximately US$ 2 billion (approximately 2% of GNP) [25, 43].

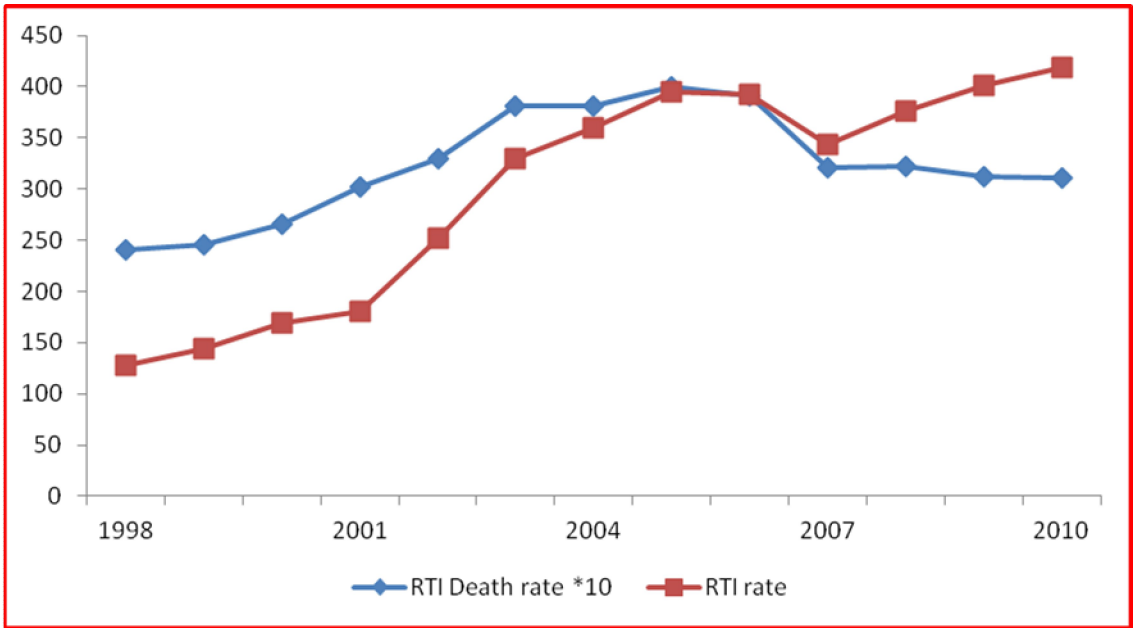

Figure 4: Trend in road traffic-related injuries and mortality rates in Iran, 1998-2010

1.5 DEMOGRAPHICS AND HEALTH TRANSITION IN IRAN

The health and demographic profile of the population of Iran is in transition [38]. Since the total fertility rate has stabilized, the age structure of the population has changed. The country is currently experiencing a “youth bulge”. In 2005, the proportion of under-15-year-olds was about 28 per cent whereas the proportion of young people aged between 15 and 24 accounted for a quarter of the total population [38]. Another significant demographic trend in Iran is urbanization of the population. In 1980, less than half of the population lived in urban areas but during the last three decades, the proportion of urban and rural population has reversed [38]. In 2009, nearly 70 per cent of the population lived in urban areas [44]. By changes in the population profile and successful control of communicable diseases, Iran now faces a burden of disease increasingly predominated by non-communicable diseases and injuries (Figure 5) [38]. As Figure 5 illustrates, the burden of disease profile in Iran is characterized by risky behaviours of young people such as traffic accidents and injuries, while non-communicable diseases such as cardiovascular disorders, cancers and mental illnesses have a continued impact.

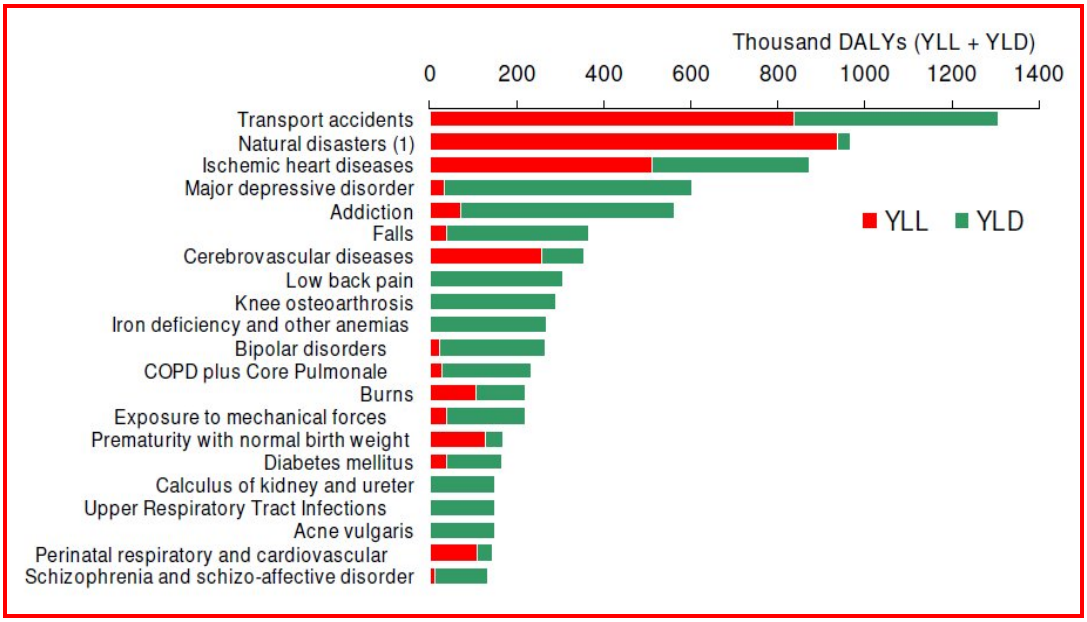

Figure 5: burden of diseases for all ages and both sexes, Iran 2003 (Natural disasters include the Bam earthquake of 26 December 2003, DALYs: Disability-Adjusted Life Years, YLL: Years of Life Lost due to premature mortality and YLD: Years Lived with Disability). Source **([37])**

1.6 MOTORIZATION GROWTH IN IRAN

Automobile manufacturing is one of the largest economic sectors in Iran and because of that vehicle ownership in Iran is significantly higher than in other countries with a similar level of income [40]. In 2006, Iran had almost six million cars and over five million motorized two-wheel vehicles [40]. The average growth rate for new registered vehicles between 1998 and 2007 was about 30% [45] (Figure 6). Among the vehicles, motorcycles had the largest growth rate with about 70% [45]. Although the road infrastructure has been developed rapidly in many cities this has not been at the same pace as the growth of motorization [40]. At the same time, fuel prices in Iran are dramatically lower than world prices [40, 46]. In addition, the cost of public transport is also significantly lower than most countries and varies considerably across provinces [40, 46].

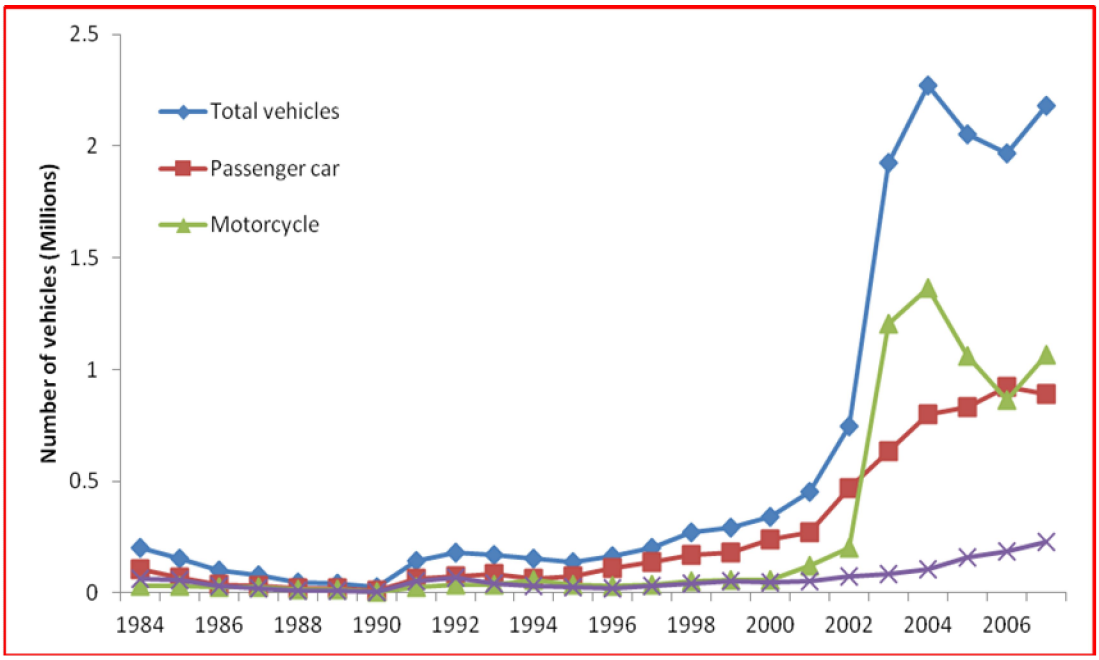

Figure 6: Motorization growth in Iran in number of vehicles, 1984-2007

1.7 THE HEALTH CARE SYSTEM IN IRAN

Article 29 of the constitution of the Islamic Republic of Iran emphasizes that all citizens have the right of access to the highest level of health [47]. The Ministry of Health and Medical Education (MOHME) is responsible for fulfilling this goal through designing and implementing national-level policies. Medical universities in the provinces (There is at least one medical university in every province) play an important role in the provision of health care services and medical education in the provinces. The chancellor of a medical university is the highest health authority in the province and reports to the Minister of Health and Medical Education [47].

Over the last two decades, Iran has made remarkable progress in the health sector with much improvement in various health indices [48]. Health care services in Iran are provided by public, quasi-public and philanthropic organizations and a large network of private providers. The public (MOHME-led) health care system, which is the main provider of health services in Iran, has a strong primary health care emphasis and is organized in three tiers: tertiary, secondary and primary health care services [48]. The public sector is the main provider of PHC services across the country and also provides a considerable part of secondary and tertiary health services [47]. The private sector mainly focuses on secondary and tertiary health care services in urban areas. There are also many non-governmental organizations active in special health issues (such as children with cancer, breast cancer etc) in Iran [47].

According to official data, nearly 90% of the country's population is covered by some type of health insurance [47]. Four major public insurance systems exist in Iran: a) The Social Security Organization (covers public sector employees and self-employed and their dependents); b) The Medical Service Insurance Organization (covers government employees, rural households, the self-employed, and others such as students) c) The Armed Forces Medical Services Organization (covers the members of the army, police and other armed forces and their dependents); and d) The Imam Khomeini Relief Committee (covers the poor and destitute) [47, 49]. In addition there are several small semi-public companies which mainly provide complementary insurance policies, covering almost 5% of the middle-class population [47]. It should mentioned that according to a newly approved law, which came into force in 2008, all hospital care for RTI victims is free of charge.

1.8 THE TRAUMA CARE SYSTEM IN IRAN

Although developing a trauma system for optimum care to trauma patients has been emphasized in the national legislations for several years, an integrated trauma system has not been established yet. Currently, several organizations are involved in prevention, management and rehabilitation of injuries but a coordinated approach for providing trauma care is still lacking [19]. Three main components of the trauma care system in Iran are presented in detail below:

1.8.1 Pre-hospital trauma care

The EMS is responsible for providing pre-hospital trauma care to injured patients in Iran, which can be accessed by the phone number 115. The EMS is centralized in the MOHME and provincial EMS centres are affiliated to the medical universities in the provinces (Figure 7) [42, 50]. EMS is mainly based on a BLS system which is provided by EMTs [19, 30]. The technicians are trained for two years in BLS skills such as intubation, triage and intravenous rehydration therapy. They also participate in periodic continuing medical education courses but the details and requirements of these courses are not well defined [19, 51].

Based on the annual surveys, EMS transfers almost one third of patients entering the EDs of hospitals (of which 37% are trauma cases) [30] and most of the patients go to the ED themselves, or with the help of family members or friends. Triage protocols are not well developed in the EMS and patients are often transported to the nearest available hospital without considering the capabilities of the hospital [19, 52].

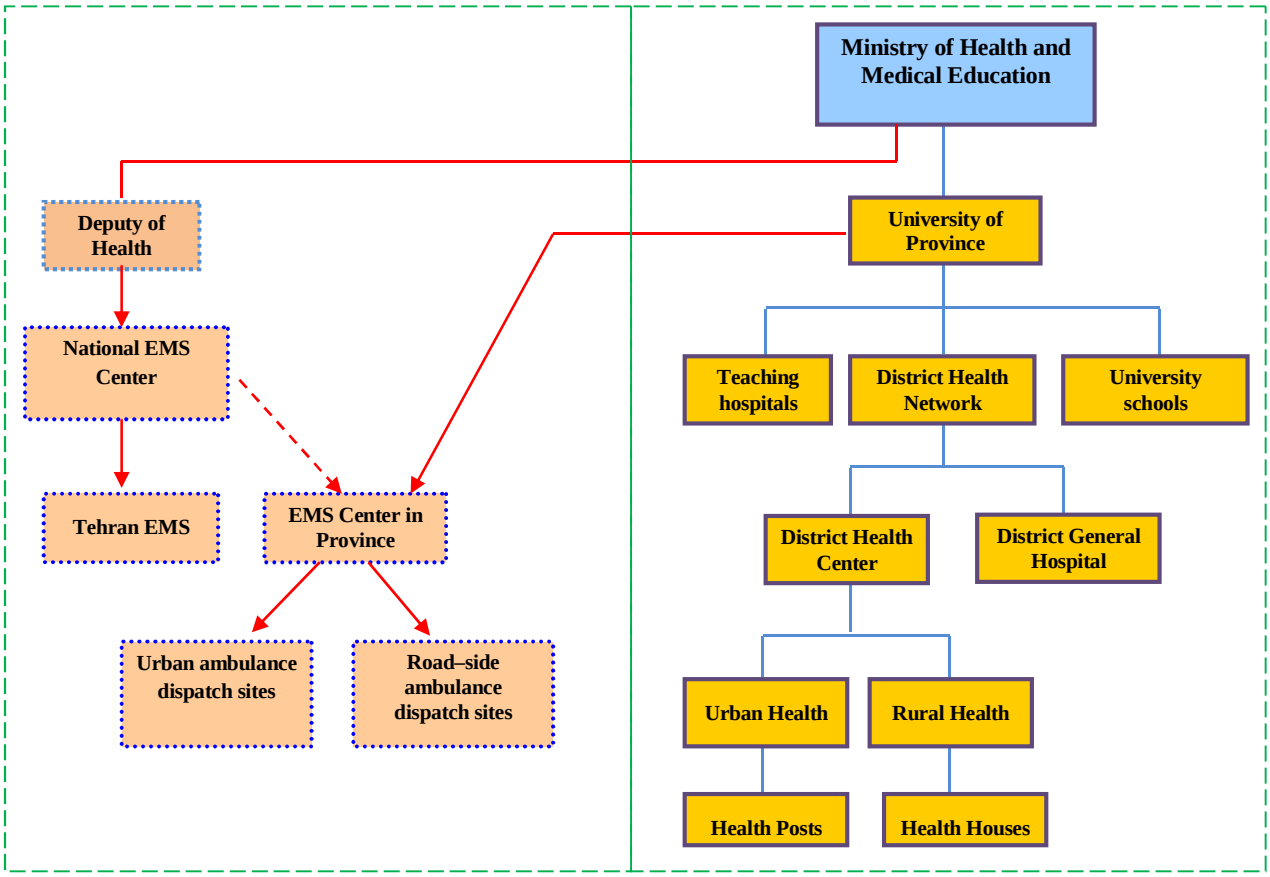

Figure 7: The Iranian healthcare system structure and position of the Emergency Medical Services (EMS)

1.8.2 Hospital trauma care

Hospitals (public and private) provide different levels of trauma care for patients in the country. Formal designation of trauma centers (into different levels based on severity of trauma and resources required for treating) has not yet been implemented in the country; however there are specialized hospitals (mainly tertiary teaching hospitals) that are equipped with required facilities and trained staff for treating injured patients. Since trauma centers are not formally designated, EMTs decide on which hospital a patient should be transferred to. This decision is usually made based on severity of injuries and the distance between the incidence scene and the potential destinations [19].

In public hospitals, nurses, general physicians and residents of surgery and emergency medicine are always available for management of injured patients. Hospital emergency services are provided by general physicians and if necessary, the emergency medicine or surgery residents visit the

patients. General physicians are taught emergency skills during their medical education; however the efficacy of this education regarding management of trauma cases is in need of re-assessment. The injured patients (after admission to the ED) are sent to a clinical ward according to their main injuries. In the case of multiple traumas, consultation from different specialists would be asked [19].

1.8.3 Rehabilitation care

Rehabilitation medicine is a recognized and well-developed specialty in the country and there are many centers providing rehabilitative care to trauma patients. However, rehabilitation is not an integrated part of trauma care and the trauma hospitals are not necessarily equipped with rehabilitation equipment and staff. Instead, trauma patients are usually referred to rehabilitation centers after discharge in the case of residual disabilities [19].

1.9 RATIONALE FOR THE STUDIES

Road traffic injuries are the second major cause of death and the leading burden of disease in Iran, involving the most productive group in society. Efforts to minimize the burden of road traffic injuries need to include both improving road safety strategies and strengthening of the trauma care system. Although evidence from HICs shows that improvements in the organization of trauma care can prevent a substantial number of death and disabilities from RTIs and other injuries, little attention has been devoted to this area by researchers and policy-makers in Iran and other countries with similar context.

In order to improve the provision of trauma care for RTIs, there is a need to identify the strengths and limitations of the current trauma care system in the country. An evaluation of the capabilities of the current trauma system in terms of resources is necessary. This should be combined with an exploration of the potential areas for improvement from the point of view of the key informants, both professionals working in this area and also RTI victims.

This thesis provides a general picture of trauma care for RTI victims in Iran by using a triangulation of different approaches. It highlights areas that need to be improved within the trauma care system from the perspective of health care professionals and injured patients. Considering the fact that there is no comprehensive study on trauma care in Iran, this thesis can contribute with information that can be of importance for policy making both in Iran and in other similar middle-income settings.

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2 AIM AND RESEARCH QUESTIONS

2.1 AIM

The overall aim of this thesis is to explore factors influencing access, provision and utilization of trauma care for road traffic injuries in Iran.

2.2 RESEARCH QUESTIONS

The following research questions will be addressed:

- Does the distribution of pre-hospital trauma care facilities reflect traffic- related mortality and injury in the provinces of Iran? (Article I)

- What are the barriers to- and potential facilitators for- providing pre-hospital trauma care for RTI victims? (Article II)

- What are the barriers to -and potential facilitators for- providing effective trauma care at emergency departments of the hospitals providing trauma care? (Article III)

- Is there a relationship between patients' socio-demographic characteristics, insurance status and injury-related factors (e.g. type of road users and safety equipment) on the one hand and hospital resource utilization on the other? (Article IV)

3 MATERIAL AND METHODS

3.1 STUDY SETTING

The thesis comprised four studies: two were conducted at a national level (Study I and IV); one was based on data both from Tehran and at the national level (Study II); and one study was conducted in Tehran (Article III).

Iran: Iran is located in the Eastern Mediterranean Region. It is the 18th largest country in the world and occupies a surface area of 1,648,000 square kilometres [44] (See Figure 8). Based on the last household survey in 2007, the country had 30 provinces, 336 districts, 889 cities, and approximately 69,000 villages [44]. In 2009, Iran had nearly 74 million inhabitants, of whom 69% live in urban areas [44]. The annual growth rate of the population in 2006 was 1.2% [44]. The total life expectancy at birth in 2009 was 73 years [44] and the adult literacy rate in 2006 was 82% [44]. The population density (people per sq. km) in 2008 was 44.2 [53]. Based on the latest classification of countries by the World Bank, Iran is classified as an upper-middle-income economy with Gross National Income per capita of US$4,520 in 2009 [53]. Iran is currently the second largest economy in the Middle East and North Africa in terms of Gross Domestic Product - US$400 billion in 2011 (after Saudi Arabia) [53].

Tehran: Tehran, covering an area of 1500 sq km, is situated in the north-central part of Iran, on the slope of the Alborz Mountain [54]. Tehran is the administrative center of Tehran Province and as the national capital it is the most populated city in Iran with a population of about 13 million inhabitants [45]. It is the centre of cultural, economical, political and social activities. About 30% of Iran's public-sector workforce and 45% of large industrial firms are located in this city [54].

Based on unofficial data, it is estimated that there are more than five million automobiles and two million motorcycles in Tehran. Moreover, every day more than 1000 new automobiles and more than 500 new motorcycles are registered and added to the number of vehicles on the road [45]. In 2010, nearly 40,000 people were injured and about 2300 died due to road traffic crashes in Tehran [55].

In Tehran city, pre-hospital trauma care is provided by the local EMS center that is directly governed by the national EMS center in MOHME [50]. There are more than 100 small and large hospitals that provide different levels of trauma care in Tehran. Currently there is no established trauma care system in the city and no hospital has been designated as a Level I trauma centre. However, a few teaching hospitals have tertiary medical care facilities [21].

Figure 8: Map of Iran [56]

3.2 DATA SOURCES

As shown in Figure 9 the thesis is structured around four studies. Studies I and IV utilize registered-based data and Studies II and III use materials based on interviews conducted with health professionals experienced in trauma care (Study II) and both health professionals and injured patients (Study III).

3.2.1 Register data

The Forensic Medicine Organization (FMO): Data about RTIs and mortalities were collected from the FMO, which is an affiliated organization of the Judicial Authority in Iran. The FMO is considered as the most reliable source of mortality data in Iran [26]. According to law, all deaths due to external causes, including RTIs, should be reported to the FMO for examination and

recording and for the issue of death certificates. The information which is recorded about the deceased victims due to RTIs by the FMO include: name of victim, socio-demographic status (including age, gender, educational level, occupation type), vehicle type, place of accident, place of death, date of accident, date of death, date of post mortem, cause of death and localization of injury. This information is recorded using International Classification of Diseases, 10th revision (ICD-10) guidelines [57, 58]. Moreover, the FMO collects data about RTI from all victims referred to the regional FMO centres all over the country. The same information is recorded for RTI victims as the deceased victims and is collected by the coroners using the same questionnaire for all FMO centres.

The Statistical Centre of Iran (SCI): Information about population size, socio-economic characteristics, number of registered vehicles, kilometres of roads and highways in different provinces was obtained from SCI. This centre was originally established in 1918 with the aim of registering vital events. SCI conducts national censuses for the total population every ten year and surveys in different fields based on population samples every year.

The Ministry of Health and Medical Education (MOHME): Information about pre-hospital care facilities is based on data from the National EMS Centre in MOHME. The Centre collects information from the Medical Universities in the provinces regarding ambulances, ambulance dispatch sites and staff.

Iranian National Trauma Registry Database (INTRD): This database was developed by the Sina Trauma and Surgery Research Center, as a part of a National Trauma Project. The database includes data from 14 general hospitals in eight major cities in Iran (Tehran, for 13 months; Mashhad and Ahwaz for 7 months; and Shiraz, Tabriz, Qom, Kermanshah, and Babul for 4 months). The data was collected between 2000 and 2004 by trained physicians using a validated questionnaire, in accordance with the American College of Surgeons National Trauma Registry System and the National Trauma Data Bank [59, 60]. During the data collection period, a group of trained physicians visited trauma patients after the first 24-hours of their admission to the hospital (at ED or inpatient wards) and completed the questionnaires. The information gathered included socio-demographic characteristics of the patients, received pre-hospital care, type and mechanism of injury (coded according to the ICD-10, Glasgow Coma Scale (GCS) and vital signs at the time of entering the ED, Injury Severity Score (ISS), diagnostic and therapeutic procedures provided, co-existing injuries, length of stay (LOS) in hospital, patient's outcome, total hospital charges and insurance type.

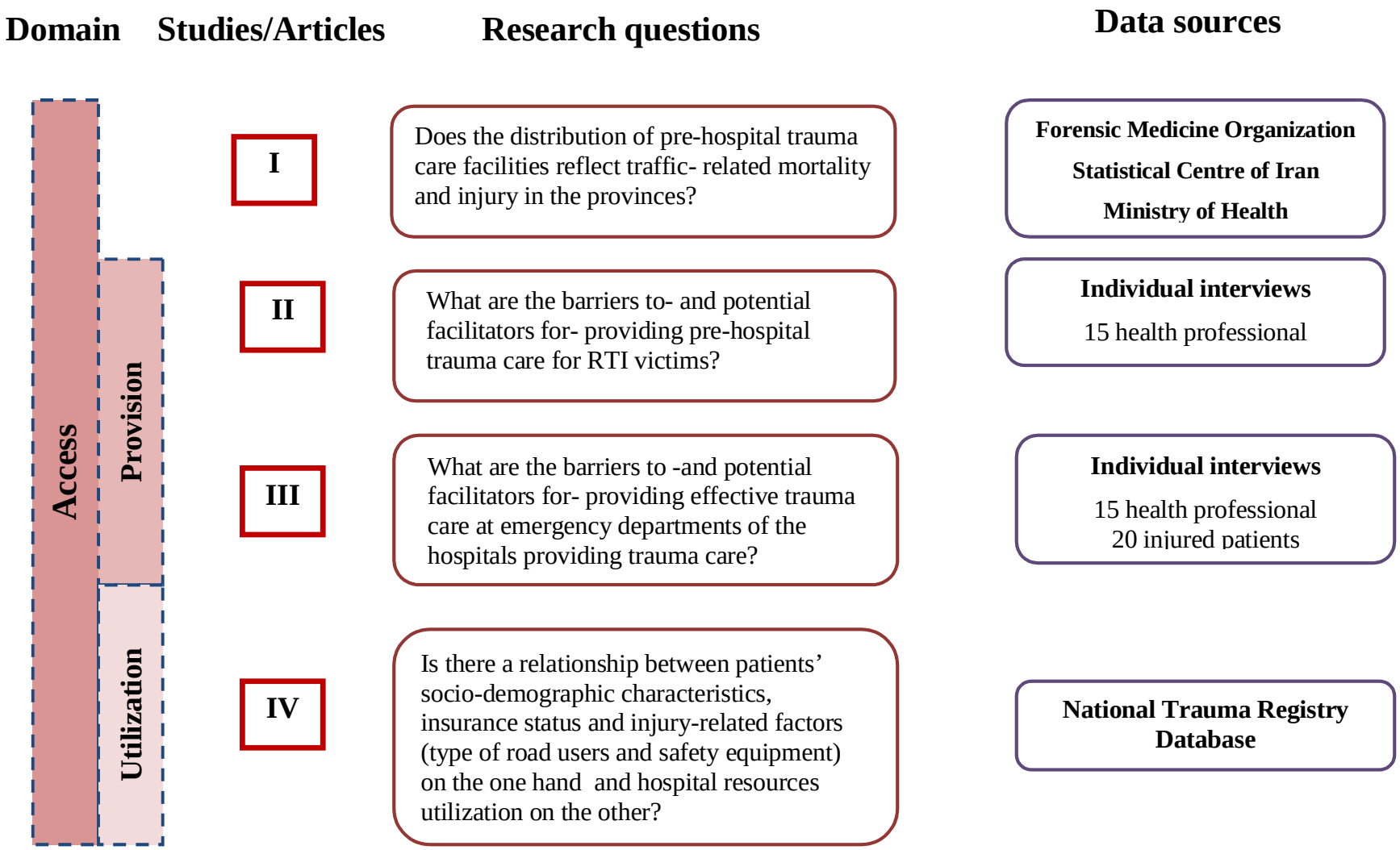

Figure 9: An overview of the research questions, study design and data sources

3.2.2 Interview data

Studies II and III were interview-based studies. In Study II, semi-structured interviews were conducted with 15 health professionals, all experienced and knowledgeable in pre-hospital trauma care, to explore factors influencing the delivery of pre-hospital trauma care for RTI victims. In Study III, 15 health professionals and 20 injured patients were interviewed in order to explore their perception and experiences regarding the provision of trauma care for RTI victims at the EDs of the hospitals providing trauma care. Employing semi-structured interviews in both Studies II and III allowed the acquisition of in-depth information about the trauma care process and opened up many new areas for investigation in future studies.

3.3 SUMMARY OF INDIVIDUAL STUDY DESIGN, MATERIAL AND METHODS

3.3.1 Study I

Pre-hospital trauma care resources for road traffic injuries in a middle-income country - a province-based study on need and access in Iran

Study I is an ecological study assessing the *distribution of pre-hospital trauma care resources* and whether the resources reflect the needs in terms of traffic-related mortality and morbidity in different provinces in Iran. This study is a national cross-sectional study covering all provinces and utilized register-based data from different data sources, including FMO, MOHME and SCI.

Number of ambulance dispatch sites, number of ambulances and number of on-duty staff (including physicians, nurses, EMTs and other paramedics working in the sites) were three variables that were used as indicators for access to pre-hospital trauma care. RTIs and RTI deaths were used as indicators for population health need for pre-hospital trauma care in different provinces.

RTI and RTI death rates per 100,000 population and pre-hospital trauma care facilities per 100,000 population were calculated for all the provinces. These rates were compared both between the provinces and also with the national average. The Lorenz Curve and Gini Coefficient were used to map the distribution of pre-hospital trauma care facilities and traffic-related injuries and mortality across the country. Using these two measures, which have traditionally been used to analyze the distribution of income and wealth [61], helped to illustrate geographical variations and equality in the distribution of pre-hospital trauma care facilities, RTIs and mortalities in Iran. Spearman rank-order correlation analysis was used in order to see if pre-hospital care

facilities were distributed based on RTI and RTI death rates. Moreover, correlation analysis was conducted between RTI and RTI death rates and traffic exposure, measured as number of vehicles (per 100,000 population) and proportion of highways in the provinces, in order to assess if the variations in traffic-related mortality and injuries can be explained by traffic exposure.

3.3.2 Study II

Barriers and facilitators to provide effective pre-hospital trauma care for road traffic injury victims in Iran: a grounded theory approach

Study II is a qualitative study aimed to explore the *pre-hospital trauma care process* for RTI victims in Iran and to identify potential areas for improvements based on the experience and perception of pre-hospital trauma care professionals. Individual semi-structured interviews in Persian were conducted with 15 health care professionals, with at least three years experience in pre-hospital trauma care, in 2007 (March-December) and 2009 (January-April). The participants included four physicians, eight nurses and three emergency medical technicians working as ambulance staff, managers or advisers in the Tehran EMS centre (ten participants), the national EMS centre in MOHME (three participants) and the Oroumiyeh EMS centre (two participants).

Each interview started with general questions about the participants' own experiences of the pre-hospital trauma care process for RTI victims and their perceptions of "factors affecting (inhibiting or facilitating) an effective pre-hospital trauma care process". Probing questions were used to clarify or gain additional information. Purposeful sampling was used in the initial interviews and was continued by theoretical sampling according to emerging codes and categories. Participant selection, data collection and data analysis continued until saturation was reached.

All interviews were audio-recorded, transcribed verbatim and analyzed according to the grounded theory model recommended by Strauss and Corbin [62]. Based on a grounded theory approach, data collection and data analysis took place simultaneously [62]. Each interview was analyzed before the next interview took place and if some important issues emerged they were then brought up in the next interview.

Following Strauss and Corbin's recommendations, data analysis was performed at three levels including open, axial and selective coding [62]. Open coding involved a line by line analysis and labelling and grouping of the data into categories and sub-categories. In this stage of coding, the principle researcher identified about 500 substantive codes and 12 categories. Axial coding involved further conceptualization of the categories and in specifying the relationships between them and in integrating them into a new form. In the axial coding stage, the lists of categories, sub-categories and codes were discussed several times within the research team and the number of categories was

reduced and major new categories were generated. In the selective coding stage, one core category which related to all other categories was identified.

3.3.3 Study III

Exploring the provision of hospital trauma care for road traffic injury victims in Iran using the Paradigm model

Study III is a qualitative study based on semi-structured interviews. The aim was to explore factors influencing an effective trauma care delivery at *emergency departments* in Iran from the perspective of both patients and professionals. The data were collected via semi-structured interviews with 15 health professionals and 20 injured patients. The health professionals included seven professionals from the EMS and eight professionals from the EDs of five hospitals providing trauma care. The injured patients included 20 patients (all male, 17 to 57 years old) with motorcycle injuries, treated in the orthopaedic departments at three different hospitals. The selection of medical professionals and injured patients initially started using a purposive sampling technique and continued with theoretical sampling to clarify and develop explored concepts and to saturate them.

The interviews with the professionals began with general questions about their own experience of providing trauma care for RTI victims and their perceptions of "factors influencing an effective provision of trauma care in the ED of the hospitals". Probing questions were also used to clarify information and to gain additional data. The interviews with injured patients were mainly focused on the barriers in the process of care that they received from the crash site to admission at the orthopedic department (including pre-hospital trauma care and care at the EDs). Additionally, four observations were done at the EDs in three hospitals as a validation of the findings of the study. Field notes were taken during the observations. All interviews and observations were done between January and April 2009 by the principle researcher.

All interviews were recorded, transcribed verbatim and analyzed based on a grounded theory approach, using the Paradigm model [63]. Open, axial and selective coding were applied to data as described in Study II. Moreover, the paradigm model was employed to explore complex relationships between identified concepts and categories with the core category. The basic purpose of this model is to enable the researcher to think systematically about data and relate identified categories and concepts [64].The components of the paradigm model technique included: causal conditions, the context, the actions and interactions or strategies taken in response to the phenomenon and the intervening factors that assist or hinder interactions and the consequences of the actions [63, 64].

3.3.4 Study IV

Factors affecting hospital resource utilization associated with road traffic-related injuries in Iran

Study IV is a register-based cross-sectional study. The aim was to assess *hospital resource utilization* associated with RTIs in Iran and evaluated the association between socio-demographic characteristics of the patients, insurance status and injury-related factors (e.g. use of safety equipment) on the one hand and hospital resource utilization on the other. This study used INTRD which included 17,753 trauma patients, among them 8,356 patients with road traffic-related injuries. The variables extracted for the analysis in this study included total hospital charges and LOS, socio-demographic status (including age, gender, education and occupation), insurance status, type of road user, injury severity measures (GCS and ISS), patient outcome (measured by in-hospital death) and use of safety equipment (helmet/seat belt) among the patients. Total hospital charges and LOS were used to assess hospital resource utilization by RTI victims. These two variables are considered as standard measures for quality of care and resource utilization in hospitals and have been used by previous trauma studies [65-67]. Total hospital charges is the amount billed by hospitals for the services for each patient and do not reflect the actual medical costs for the injury.

Univariable analysis using non-parametric methods and multivariable ordinal regression analysis were performed to identify the factors associated with total hospital charges and LOS. In univariable analysis, Mann Whitney U test and Kruskal-Wallis tests were used to compare the LOS and total hospital charges in sub-categories of patients' demographic and injury characteristics. Moreover, Chi-Square and Mann-Whitney tests were used to compare the proportion of in-hospital deaths and total hospital charges/LOS, respectively, among people who used safety equipment (helmet/seat belt) and those who did not use safety equipment.

In the multivariable regression analysis, total hospital charges and LOS were dependent variables and age, sex, education, occupation, insurance status, ISS, GCS, road user type and death in hospital (and LOS for the model in which hospital charges was considered as a dependent variable) were independent variables. A P-value of <0.05 was considered statistically significant.

3.4 ETHICAL CONSIDERATIONS

Studies I, II and III were approved by the National Ethics Committee of the Ministry of Health and Medical Education (Ref no. P 917 /10- March 2010) and the ethical clearance for the Study IV was obtained from the Sina Trauma and Surgery Research Center (Ref no. 421/106785- August 2011). Verbal consent was obtained from all participants in Studies II and III and all participants were informed about the purpose of the study and that their participation was confidential, anonymous and voluntary.

4 SUMMARY OF RESULTS

4.1 STUDY I

Does the distribution of pre-hospital trauma care facilities reflect traffic- related mortality and injury in the provinces of Iran?

Comparing pre-hospital trauma care facilities, RTI and RTI death rates among the provinces showed that there are substantial differences in distribution of the facilities and traffic-related injuries and mortalities across the country. The national average of RTI death was 39 per 100,000 population and it varied almost four-fold across the country. There were similar differences for RTIs which ranged from 718 per 100,000 population to 197 per 100,000 population. The national average number of ambulances was 3 per 100,000 population, ranging from 2 to 8.3 per 100,000 inhabitants. Average number of ambulance dispatch sites was 1.8 per 100,000 population and varied from 1 to 5.1 per 100,000 inhabitants between the provinces. Substantial differences were also observed in the distribution of staff across the provinces. The difference between the province with the highest number of staff and the province with the lowest number of staff was six-fold.

The results from the Lorenz curves and Gini coefficients pointed in the same direction, demonstrating inequality in the distribution of pre-hospital trauma care facilities and RTI/death across the country.

The results of the correlation analysis between the need and access indicators showed that there was no significant association between RTI and RTI death rates on one hand and pre-hospital trauma care facilities on the other. Moreover, correlation analysis of RTI/death and proxy variables for traffic exposure (number of vehicles and proportion of highways in each province) showed that there were no significant associations between RTI death rate and number of vehicles or proportion of highways, while there was a weak significant positive association between RTIs rate and proportion of highways.

4.2 STUDY II

What are the barriers to- and potential facilitators for- providing pre-hospital trauma care for RTI victims?

Seven categories emerged to describe the participants' point of view regarding factors that hinder or facilitate an effective pre-hospital trauma care process. These factors included: (1) administration and organization, (2) staff qualifications and competences, (3) availability and distribution of resources, (4) communication and transportation, (5) involved organizations, (6) laypeople and (7) infrastructure. A conceptual model was developed based on the categories which illustrates factors that can influence the pre-hospital trauma care process (refer to Figure 2 in Article II). In this model, the pre-hospital trauma care process is illustrated by an arrow and is divided into four main stages (inspired from available knowledge in the literature [12, 13, 68, 69]: Early notification, early response (or dispatch), efficient on-scene care and safe and prompt transportation. In the model each category by itself or in interaction with others can facilitate or inhibit an optimal pre-hospital trauma care process by influencing each of the main stages of the process. The categories were divided into factors inside the EMS and factors outside the EMS. The core category that emerged from the other categories was defined as "interaction and common understanding".

Factors inside the EMS

Administration and organization: Existing misconceptions about the EMS, inappropriate management, inefficient structure and rules and regulation were certain aspects of administration and organization that were seen as barriers to an effective pre-hospital trauma care process. Examples of common misconceptions among health policy makers and EMS managers were "The EMS is a superfluous and expensive part of the healthcare system" and "the duty of EMS is solely to transport victims to a medical center". These misconceptions were perceived as important factors affecting the development of the EMS in the country.

According to the participants, EMS in the provinces have a different structure, which leads to a lack of coordination between EMS centers, especially in mass trauma situations. They also mentioned that some official rules and regulation restrict the employment of experienced physicians and also limit the responsibility of experienced nurses to treat patients. The main issues regarding management of the EMS, discussed by the participants, were unqualified and unstable management, lack of protocols and inadequate training plans for staff.

"A constant turnover of managers is another issue. We have had nine managers over the past nine years. Each one was replaced by another person

after having gained experience about the EMS and making some new policies or plans". (Participant 3)

Staff qualifications and competence: Shortages of professional medical staff and the inadequate skills and knowledge of the current staff in EMS were among the major issues discussed by the participants. Lack of training plans about pre-hospital trauma care and out of date, unpractical and inadequate training courses were perceived as the main reasons for inadequate knowledge and skills among the staff. This resulted in malpractice, conflicts among staff members (especially between the ambulance staff and consultant physicians) and interference from untrained laypeople.

"We have a lot of useful training courses but management doesn't ensure that these courses are practical. New text books are used for the training courses, but in reality we use the same procedures as we always have". (Participant 2)

Availability and distribution of resources: According to the participants, resource deficiency and inappropriate distribution were critical barriers to providing effective pre-hospital trauma care. Shortage of professional staff, ambulances and dispatch sites, lack of necessary equipment in the ambulances (including rescue equipment) along with the long distances between ambulance dispatch sites, and substandard road-side dispatch sites were some of the factors that contributed to the deficiencies of the resources.

Communication and transportation: The participants discussed that the limitations of the communication system (such as an insufficient number of radio channels and a shortage of equipment) and ineffective medical direction and a poor referral system are major barriers when providing care on the scene or when transporting the victims to the hospital. Inefficient medical direction was considered to be a consequence of the communication system limitations, consultant physicians with a lack of experience and staff with inadequate skills. Moreover, the main limitations of the current referral system were out-of-date maps and lack of Satellite Navigation (GPS) which along with an inappropriate communication system between the EMS and the hospitals contributed to a delayed transportation of the victim to hospitals

Factors outside the EMS

Involved organizations: In addition to the EMS, other organizations including the Police, the Red Crescent and the Fire Department are involved in the management of a crash and the rescue of crash victims in Iran. According to the participants, poor coordination and cooperation between these organizations and the EMS and the insufficient knowledge and skills regarding the rescue of victims and managing the crash were important obstacles to providing prompt and effective pre-hospital trauma care at the crash scene and when transporting the victims to hospital. The participants explained that each organization arrives at the crash scene at different times and there is

no communication or a common telephone line between these organizations that can be used for coordination and information exchange.

> *"The police staff are usually bystanders at the crash scene like other laypeople. They only do paper work related to the crash (take statements)". (Participant 2)*

> *"The Red Crescent staff are mainly volunteers and they are not qualified to treat some types of trauma patients, they take action because they usually are the first on the scene. The Fire Department staff come to the scene to extinguish fire or to rescue the victims, but they don't know anything about basic medical care or first aid, even though they have it on their curriculum. They pull out or lift the victims in an unsafe way that may threaten the victim's health". (Participant 1)*

Laypeople: According to the participants, the involvement of laypeople at the crash scene is perceived mainly as negative. Some of the factors that were contributed to this negative perception about laypeople role included their providing incomplete or wrong information by laypeople, and their emotional reactions and conflicts with the EMS personnel. The factors mentioned as the main reasons for the involvement of laypeople at the crash scene included cultural values and beliefs (willingness to help), lack of knowledge about their role at the crash scene, the late arrival or lack of competence of EMS staff and also laypeople's mistrust of EMS staff.

> *"Laypeople interfere with the EMS technicians at the scene and distress them so they can't focus carefully on their work and they have to take victims without doing routine examinations …" (Participant 1)*

Furthermore, other important issues discussed by the participants were the lack of public educational plans about providing first aid at the crash scene. They indicated that there is inadequate collaboration and interaction between the EMS and the media concerning public education. They also noted that the role of other involved organizations about public education (including laypeople) is not clear either.

> *"… there is not any public education about prevention of crash mortalities or injuries…. There is no interaction between the EMS and the media about public education. This is because EMS managers don't believe that public education is a part of the EMS mission". (Participant 1)*

Infrastructure: Lack of a GPS system, sub-standard road infrastructure, lack of infrastructure for helicopter ambulances in the big cities, and an inadequate telecommunication system were common deficiencies in the infrastructure mentioned by the participants.

4.3 STUDY III

What are the barriers to -and potential facilitators for- providing effective trauma care at emergency departments of the hospitals providing trauma care?

"Lack of a systematic approach for providing trauma care at emergency departments" was identified as the core category, which reflects the views of the participants regarding factors inhibiting the provision of effective trauma care at hospitals. The relation between the core category and the concepts and the categories identified in the study is illustrated based on the Paradigm Model (refer to Figure 1, in Article III). The findings will be described according to the developed Paradigm Model.

Causal conditions

In this study, the causal conditions are seen as events or happenings that lead to the occurrence or development of a non-systematic trauma care delivery. Absence of a national trauma care system and a non-integrated pre-hospital and hospital trauma care system were important issues at the national level discussed by the participants

> *"Pre-hospital and hospital processes are separated from each other. When we transfer a patient to the ED, they start to examine the patient again to decide what treatment the patient needs.... The process of treatment should start in the ambulance and continue in the hospital...". (Professional 5)*

At the hospital level, absence of trauma teams, inefficient triage systems and lack of protocols and guidelines for traumas and inappropriate human resource planning in the hospitals providing trauma care were mentioned as the major factors contributing to poor organization of trauma care. According to the participants, inappropriate allocation of staff (not based on patient load) in the EDs, employing inexperienced staff and lack of or inefficient trauma-related training courses were the main reasons for inappropriate human resource planning.

Contextual conditions

Contextual conditions are a set of conditions that create circumstances or problems to which groups or individuals respond by their actions/interactions [63]. Factors such as inappropriate structure of the hospital, shortage of professional and non-professional staff and unsuportive envirnment were considered as the contextual condition.

Being a teaching hospital, because of having a series of common problems such as repetition of activities, conflicts between educational and non-educational groups, was identified as one of the structural limitations. Moreover, inappropriate access to other departments (such as MRI, CT-scan, laboratories, ICU and surgery), which are highly utilized by the ED, lack of infrastructure for helicopter landing, shortage of physical

space and ineffective design of the ED were other hospital structural limitations discussed by the participants.

> *"As the hospital building is very old, the CT-scan is far from the ED and is located on the other side of the hospital…. This has a significant effect on the care provided for patients and causes dissatisfaction". (Professional 14)*

Unsupportive environment was another contextual condition. Absence of established ways for communication and interaction, insufficient mutual trust and low economic incentives were main factors which contributed to an unsupportive environment. The participants commented that there is a lack of trust between different specialist groups in the ED, between the patients (or their attendants) and ED staff and between the ED and EMS staff. Mistrust between the EDs and EMS staff was partly perceived as lack of knowledge about each other's duties, qualifications and skills.

> *"ED staff usually don't ask for and don't trust our medical reports and activities done for the patients. It depends on the hospital. Some hospitals, where Emergency medicine physicians (EMPs) teams are in charge of the EDs, ask for our reports and the procedures we have done for the patients". (Professional 2)*

Intervening conditions

In this study, the intervening conditions are the broader structural context affecting the trauma care delivery system. These conditions either facilitate or constrain the action/interactional strategies taken within a specific context [63]. Factors, such as an increasing number of injuries in the country and also providing free-of-charge hospital trauma care for RTI victims (a newly approved national policy) could be seen as intervening conditions, which have increased trauma care demand.

Actions/ Interaction strategies

Action/interaction strategies are purposeful courses of action, which are taken by individuals or groups in response to events, problems or issues which occur under certain conditions [63]. Different actors involved in providing trauma care reacted in different ways in order to deal with factors influencing the trauma care delivery. For example, EMP teams have made several changes (in facilities and equipment, training of staff and the process of care) in the hospital where they were in charge. Other common reactions included: the employment of newly graduated or inexperienced staff by the hospitals' management in response to the shortage of staff; high turn-over of staff because of stressful environment of the ED and low economic incentives; lack of cooperation between different actors both inside and outside the hospitals; and interference from the patients' attendants.

"Because there is not a coordinated and united system in the ED, different specialist groups and wards do not cooperate with each other for providing care". (Professional 8)

Consequences

The consequences are outcomes of the action/interaction strategies chosen by the actors[63]. The strategies employed by different actors involved in providing trauma care at the EDs in general resulted in ineffective trauma care, although in some cases, improved the quality of trauma care. In the hospitals where an EMP team is in charge of the ED, the local changes which they have made in organization of care, equipment and staff training in order to deal with the situation have improved the quality of trauma care. These changes have resulted in shorter waiting and treatment time, and increased satisfaction among patients. On the other hand, strategies such as high turnover of staff and employment of inexperienced and unqualified staff in order to compensate for the shortage generally resulting in delays and prolonged treatments, and caused dissatisfaction among patients, their attendants and staff. These factors have also, in some cases, caused malpractice and increased adverse effects among patients.

4.4 STUDY IV

Is there a relationship between patients' socio-demographic characteristics, insurance status and injury-related factors (type of road users and safety equipment) on the one hand and hospital resources utilization on the other?

General characteristics of the study population

Of 8356 RTIs victims, 77% were male and the mean age was 30.75±18.1 (median, 26). The 15 to 29 years age old had the highest incidence of RTIs (41%) and most patients (29%) had elementary and intermediate education. 58% of the patients did not have any type of insurance.

Most victims were pedestrians (41%) and only 5% of the car occupants had used seat belts and 5% of motorcyclists had safety helmets. Five percent of the victims died in hospital. Moreover, 63% of the patients were transported to the hospital by means of transportation other than ambulance, and only 13% were transported by EMS ambulances. 53% of the patients had an ISS of 1-7 and a majority (88%) had GCS of 13-15.

Total hospital charges and LOS

The mean total hospital charges for the patients were 1,436,938 Rials (± SD=2,525,512 Rials, US$165± US$290). This ranged from 0 to 87,204,275 Rials (US$ 0- US$

10,000). The mean LOS for the patients was 6.8 days (±SD=8 days). LOS ranged from 1 day to 105 days, with a median of 5 days. Table 1 presents mean and median total hospital charges and LOS according to socio-demographic and injury characteristics of patients.

The results of univaraiable analysis showed that sex, education level, insurance status, occupation, road user type, injury severity (ISS and GCS) and in-hospital death are significant predictors of LOS and total hospital charges. On the other hand, there were no significant differences in LOS and hospital charges between different age groups.

The results of multivariate analysis of total hospital charges (after adjusting with other socio-demographic and injury characteristics) showed that increasing age, being female, having a lower level of education, higher ISS, lower GCS and higher LOS was associated with higher hospital charges. At the same time, being injured as a pedestrian was associated with lower hospital charges. Multivariate analysis of LOS showed longer LOS were associated with being male, having lower education, having a medical insurance, being a farmer or a blue-collar worker, having higher ISS score and having lower GCS score. On the other hand, the patients who died in hospital, car occupants and bicycle riders had shorter LOS.

Use of safety equipment (seat belt/helmet)

Comparing in-hospital death among users and non-users of safety equipment showed that in-hospital death for patients who used a seat belt was 3.4% compared to 6% for patients who did not use a seat belt, although this difference was not statistically significant (p=0.480). On the other hand, none of the injured patients who used safety helmets died in hospital compared to 3% of those who did not use a helmet. This difference was statistically significant (p=0.021).

The analysis of using safety equipment and hospital resource utilization showed that the patients who did not use safety helmets had longer LOS and higher hospital charges compared to patients who used helmets, although the difference failed to attain statistical significance (p=0.089 and p=0.116 for LOS and hospital charges, respectively). Patients who used a seat belt had higher hospital charges compared to patients who did not use a seat belt (p=0.020), but the difference in LOS was not significant between the two groups (p=0.126).

Table 1: Mean and median total hospital charges and length of stay (LOS) based on socio-demographic and injury characteristics of road traffic victims included in the INTRD, 2000-2004.

Characteristics		LOS		Total hospital charges (Rials)	
		Mean	Median	Mean	Median
Sex	Female	6.0	5.0	1,302,106	658,517
	Male	6.6	5.0	1,476,234	759,651
Age	<= 4	6.1	3.0	1,095,936	545,476
	5 - 14	6.4	5.0	1,143,395	565,965
	15 - 29	6.4	5.0	1,481,212	780,540
	30 - 44	6.6	5.0	1,457,184	698,107
	45 - 59	6.3	5.0	1,372,171	708,283
	60+	6.8	5.0	1,757,578	850,118
Occupation	Retired	6.3	5.0	1,886,117	688,421
	Armed forces	6.0	5.0	1,453,949	722,592
	White-collar worker	6.1	5.0	1,329,644	600,000
	Blue-collar worker	7.2	5.0	1,557,842	942,782
	Farmer	7.5	7.0	1,758,576	994,062
	Others	6.3	5.0	1,359,654	683,963
Medical insurance	No	6.0	5.0	1,298,073	618,516
	Yes	7.0	5.0	1,551,640	833,796
Road user type	Pedestrian	6.6	5.0	1,415,181	695,376
	Car occupant	6.1	5.0	1,408,455	632,424
	Motorcycle rider	6.6	5.0	1,521,046	856,347
	Bicycle rider	5.4	5.0	992,903	523,595
	Others	7.2	5.0	1,592,865	1,022,791
ISS	1-7	5.6	3.0	990,512	502,903
	8-12	8.0	7.0	1,942,716	1,276,828
	13+	7.2	5.0	2,246,595	1,175,200
GCS	3-8	6.3	3.0	3,053,315	1,137,712
	9-12	8.1	7.0	2,298,359	1,262,611
	13-15	6.4	5.0	1,293,736	697,499
Died in hospital	No	6.6	5.0	1,412,840	739,331
	Yes	3.8	1.0	1,984,243	382,922
Use of seat belt	No	6.0	5.0	1,359,293	625,728
	Yes	6.1	5.0	1,603,448	1,094,208
Use of helmet	No	6.7	5.0	1,531,994	856,792
	Yes	5.8	5.0	1,217,979	782,023

†One US Dollar in 2004 was on average equal to 8,719 Iranian Rials
INTRD: Iranian National Trauma Registry Database, ISS: Injury Severity Score, GCS: Glasgow Coma Scale

5 DISCUSSION

The thesis brings up important issues regarding access, provision and utilization of trauma care for road traffic injury victims in Iran. The findings show that pre-hospital trauma care resources across the country were not distributed based on needs in terms of traffic-related mortality and morbidity. For the provision of trauma care, the studies identified that there is a lack of interaction and common understanding among different actors involved in the pre-hospital trauma care system and a non-systematic approach is the main barrier to managing trauma patients in the EDs. The findings indicated that the hospital resource utilization associated with RTI victims is substantial and varied based on the victims' socio-demographic characteristics, insurance status and injury-related factors. The findings will be discussed based on the three concepts; access, provision and utilization of trauma care.

5.1 ACCESS TO TRAUMA CARE

Several studies have mentioned the inadequacy of a public health infrastructure and poor access to health services, including trauma care, as major reasons for the high burden of RTIs in LMICs [10, 17]. Evidence from HICs and a few LMICs indicates that a substantial number of deaths and disabilities could be prevented by improved access to trauma care facilities [1, 11]. All studies in this thesis identified various dimensions of access to trauma care. The findings will now be discussed based on two aspects of access; availability of trauma care and distribution of resources.

5.1.1 Availability of resources

Shortage of trauma care resources is prevalent in many LMICs [1, 16, 17]. In Iran, based on our studies, shortages of trained staff in trauma care, essential equipment and infrastructures both in pre-hospital trauma care and in hospital care were found to be the main problems. These issues have limited many injured people's access to the necessary trauma care or deprived them of it entirely.

Barriers to pre-hospital trauma care such as the shortage of trained professional staff (e.g. general physician, EMT and nurses), ambulances and dispatch sites and also the lack of essential equipment in the ambulances (e.g. defibrillator and monitoring equipment, rescue equipment) were reported by the key informants in Study II. The inadequate supply of pre-hospital trauma care resources has also been mentioned in a study conducted in Tehran, Iran [70] and has also pointed out in other LMICs [17].

Shortages of pre-hospital trauma care resources in the country could be considered as the main reason for the low usage of EMS ambulances and the long transportation time

shown in Study IV and also in previous studies in Iran [33-35]. In line with previous Iranian trauma studies [33, 71], our findings showed that the majority of trauma patients admitted to the hospital had injuries of moderate severity. This can probably be explained by the fact that many severely-injured patients die before reaching the hospital due to severe crashes, long pre-hospital transportation time and, insufficient pre-hospital trauma care facilities [50, 72]. During recent years, substantial improvements have been made to pre-hospital care facilities, both in terms of physical and of human resources [73]. Further research is needed to evaluate the potential effects of these improvements on pre-hospital transportation time intervals (especially response time) and also on health outcomes of the patients.

In hospital settings, particularly EDs, a shortage of professional staff (especially nurses) is a common problem. Limited of financial resources and legal restrictions regarding the employment of professional staff were the main reasons for this shortage that were discussed by the participants in Study III. Such a shortage in the health sector is a common problem in many LMICs [1, 3, 17]. In contrast with studies from other LMICs where the shortage of essential equipment and supplies have been shown to be a major problem [1, 3, 17], our findings indicate that the majority of hospitals providing trauma care in Iran do have the essential equipment and supplies for managing trauma cases, however, whether the equipment and supplies are used properly is another issue which requires further research.

Based on the findings of Study III, many hospitals had an undeveloped infrastructure. For example, very few hospitals had helicopter platforms and in the majority, shortage of physical space and ineffective design of the ED was a common problem, which limited quick and easy access to other departments. These findings confirm the results from a local study showing similar results regarding shortage of physical space and infrastructure deficiencies [74]. It has to be emphasized that improvement of the infrastructure might be difficult in the short run since most hospitals are old and to improve their physical structure would be very expensive.

5.1.2 Distribution of resources

Distribution of resources was another aspect of access to trauma care that was assessed in this thesis. Studies on the distribution of general health care resources, including human and physical resources, in LMICs is well-documented but based on our knowledge there is no published study in the literature which specifically focus on the distribution and accessibility of trauma care resources.

Based on the findings from Study I, there were substantial differences in the distribution of pre-hospital care facilities (ambulance, staff and dispatch sites) across the country. For example, there was nearly a four-fold difference in the number of ambulances and dispatch sites per 100,000 inhabitants between the provinces. The difference was even higher for trained staff (almost six-fold).

The findings from Study I also showed that the distribution of pre-hospital trauma care facilities was not based on the distribution of road traffic related mortality and morbidity in the country. This issue also emerged in Study II, where participants reported an uneven distribution of resources. One possible explanation for this lack of balance in the relationship between pre-hospital trauma care facilities and RTIs/deaths could be that the allocation of pre-hospital trauma care facilities is mainly based on number of inhabitants in each province [75] and not on the crash rate and environmental risk factors. Furthermore, the general lack of resources in pre-hospital trauma care obviously affects the possibility to distribute trauma care where it is most needed.

Considering the fact that the majority of RTI deaths in Iran (like other LMICs [16, 24]) occur in the pre-hospital phase and before arrival at the hospital [25, 26], improvement of the pre-hospital trauma care facilities is crucial in order to ensure access to trauma care for people in need of care. Evidence from HICs and LMICs indicates that improvements in pre-hospital trauma care can prevent a substantial number of deaths and disabilities from RTIs [29, 30]. For example, in Mexico [29] an increased number of dispatch sites for ambulances and the establishment of regular training courses for ambulance attendants resulted in reduced pre-hospital time and a decreased mortality among transported trauma patients from 8.2% to 4.7%.

5.2 PROVISION OF TRAUMA CARE

To reduce road traffic-related mortality and disability requires an integrated system of care with effective initial assessment and treatment at the scene of the incident, followed by efficient transport to hospital, high quality care in the ED and in the hospital and a well organized rehabilitation [7, 76]. Therefore, a systems approach should be considered, where improvements need to be made to the whole system of trauma care and the benefits from improving one part will only be maximized if all parts are strengthened [7].

The following text presents important issues in relation to the provision both pre-hospital and hospital trauma care, that were identified in Studies II and III. These issues should be considered for strengthening the trauma care system.

5.2.1 Pre-hospital trauma care

5.2.1.1 Administration and organization

Inappropriate administration and organization were identified as critical issues that influenced development and effective provision of pre-hospital trauma care in Iran. In contrast to Mock et al [17], who mainly focused on supply and utilization procedures,

the findings from Study II are mainly concerned with issues such as inappropriate structure, suboptimal and unstable management, lack of documented protocols and inadequate training plans for staff. Moreover, there were a number of misconceptions among health policy makers and EMS managers about the role of EMS, which are considered to be a major barrier to the development of the EMS. These misconceptions have also been previously discussed in the literature [13]. Lack of documented, evidence-based protocols for pre-hospital trauma care is an important barrier to effective provision of pre-hospital trauma care. This issue has also been discussed by Khashayar et al in a recently published article, evaluating the efficacy of pre-hospital care for trauma patients in Iran [51].

5.2.1.2 Knowledge and skills of staff

In line with studies from Ghana and Mexico [17], Study II identified inadequate knowledge and skills of staff as an important barrier. The main reasons for this problem in the context of Iran could be explained by poor educational plans and lack of up-to-date protocols and training courses. This differs from other LMICs that mainly rely on staff and volunteers with only on-the-job training and without any formal training, such as the EMT certification [17, 77]. The high number of formally educated staff in Iran makes it possible to develop a comprehensive educational plan for pre-hospital trauma care and to link the staff's education and practice by implementing evidence-based training courses. This can be done by the help of EMPs who are perceived to have had an important role in improving the quality of trauma care in recent years [51, 78]. Evidence from other LMICs has indicated that training staff in BLS, such as Pre-hospital Trauma Life Support (PHTLS) program [29, 79, 80] and providing EMT certification [77] are effective ways to decrease injury-related mortality and morbidity. For example, in Mexico [29] the establishment of regular PHTLS courses for ambulance attendants decreased the mortality among transported trauma patients from 8.2% to 4.7%. Similar improvements in trauma care and a decrease in mortality (from 15.7% to 10.6%) were seen in Trinidad when they established regular PHTLS courses for staff [79, 80]. However, there is no rigorous evidence regarding the effect of training of staff in ALS skills on patient survival in both HICs and LMICs [3, 14, 81].

5.2.1.3 Communication and transportation

An effective communication network and rapid transportation are critical elements of a pre-hospital trauma care system [1, 13]. Based on the findings from Study II, the communication system in the EMS was suboptimal. Some of the main limitations included large areas with no radio coverage, insufficient number of radio channels and shortages of equipment. These had negative effect on the performance of the referral system and prompt transportation of patients to the hospitals, because of difficulties in notifying the hospitals of the need to transfer the patients. They also had a negative effect on the process of medical consultations for the injured patients, both at the crash

scene or when transporting the patients. Moreover, weaknesses of the EMS current referral system, such as out-of-date maps and absence of GPS cause delays in the transportation of the patients to the hospitals.

5.2.1.4 Coordination of involved organization

Provision of effective on-scene care and prompt transportation to a hospital, require close coordination between rescue teams, the police and the EMS staff [23]. The findings in Study II are consistent with a previous study [82] that indicated that there is poor coordination and cooperation between different organizations involved in the rescue services at the scene of the crash and during the post crash process. These organizations have different emergency telephone number, and this can be one of the reasons for poor coordination between them. An integrated emergency dispatch or a central call reception is one strategy recommended by WHO [16] for enhancing coordination between these organizations. The WHO [16] has also suggested that since the police and firefighters often arrive at the crash scene before the EMS personnel, they need to be trained in BLS skills.

5.2.1.5 Laypeople's involvement

Laypeople are the first responders in many countries and they are often trained to provide basic first aid for the victims before the arrival of more formally trained rescuers [16]. In Study II, the negative involvement of laypeople was indicated as an important barrier to effective provision of pre-hospital trauma care which is in line with another study in Iran [82]. Different explanations are given as to why the involvement of laypeople is negative including cultural beliefs, lack of knowledge about emergency care and first aid and lack of public education programs. According to WHO [16], the media (especially TV in the Iranian context) can be used to train the public to recognize emergency medical situations, to call for help, and how to provide first aid. Training specific target groups (such as public car drivers) is another efficient way to improve pre-hospital trauma care [16]. Training laypeople in first aid skills has been demonstrated to be effective in several studies in LMICs [83-85]. For example, training laypeople and paramedic staff in providing first aid in mine-infested areas of Iraq and Cambodia showed that mortality among severely injured persons decreased from 40% to 9% [85]. However, a similar study in a rural area of Iran showed no difference in injury mortality among patients as a result of first responders (laypeople and paramedic) training although the physiological status of the transported victims improved [86].

5.2.2 Hospital trauma care

5.2.2.1 Absence of an integrated trauma system

Based on WHO, a prerequisite for effective trauma care in the EDs is existence of an organized national trauma system [12, 23]. Evidence, mostly from high-income countries, indicates that a well-organized trauma care system can reduce trauma deaths and disabilities substantially [1, 7, 11]. Considering the high burden of injuries, especially RTIs in Iran, the establishment of such a system is necessary. Although establishing a comprehensive trauma care system has been mentioned in the national legislation and has been emphasized by several studies in Iran [19], this goal has not yet been achieved.

In Iran there is no national lead agency to co-ordinate various components of the trauma system. The main components, especially the pre-hospital and hospital trauma care provision are separated from each other and this interrupts the continuity of trauma care from pre-hospital care to hospital care. Studies in HICs shows that properly coordinated early rescue and retrieval systems together with an effective and early trauma management in hospital will prevent 15 - 30% of deaths due to RTI [76].

5.2.2.2 Organization of trauma care

Most studies have confirmed substantial reduction in mortality as a result of improvements in the hospital's organization of trauma care [1, 11, 17, 87]. In Study III, organization of trauma care at EDs was considered poor due to the issues such as absence of trauma teams, lack of protocols and guidelines for trauma care and inappropriate human resource planning (including recruiting and training). These findings confirm findings from a recently published study, emphasizing on the lack of trauma teams and trauma training in hospitals [88].

It is difficult to quantify how poor trauma management at the hospitals contributes adversely to the patient outcome in the country. However, a study that evaluated trauma deaths in the two largest teaching hospitals in Tehran indicated that 26% of the trauma deaths were preventable. Most of the preventable deaths were related to non–central nervous system–related deaths. This study also reported that sixty-four cases of medical errors were identified in 31 trauma deaths and 80% of these errors were directly related to the death of the patients [27].

Different methods and strategies have been recommended for improving the organization of trauma care at hospitals [1, 2]. Establishment of trauma teams and training of staff are two important strategies that have been demonstrated to be effective in improving the outcome of trauma patients in both HICs and LMICs [1, 89-91]. For example, establishment of a trauma team at an urban trauma centre in Turkey showed

that, in addition to reducing unexpected deaths, deaths due to severe injuries were decreased by 10%. These improvements were perceived as being caused particularly by improved resuscitation airway management [89]. Morover, in another study, Ali et al.[90, 92] reported that a two-day continuing education course in advanced trauma life support in Trinidad reduced the mortality of severely injured patients attending hospital, from 68% before the training period to 34% after the training.

5.2.2.3 Interaction between different stakeholders

Improving trauma care is necessarily a collaborative process involving key stakeholders, including clinicians, managers, patients and caregivers [7]. Poor interaction between different actors involved in trauma care including clinicians (specialists and other ED staff), EMS staff and patients and their attendants was emphasized as a problem in Study III. Lack of established ways of communication between different actors was perceived as the main reason for the poor interaction. There was also poor communication between different hospitals regarding transferring injured patients. This issue that has also been highlighted by another study in Iran [88], can be facilitated by inter-hospital transfer agreements and protocols [1].

5.2.2.4 Role of Emergency Medicine Physicians (EMPs)

One of the advantages of the health care system in Iran is the existence of Emergency Medicine as a specialty. Few LMICs have specialists in emergency medicine, and in many countries this is not recognized as a specialty of its own [7]. The specialty was developed in Iran in 2000 [78] and qualified EMPs have been involved in providing trauma care for several years. The findings of the Study II showed that the EMPs have improved the delivery of trauma care in their own ED mainly by improvements in staff training and equipment and facilities in the EDs. The positive influences of EMPs on the quality of pre-hospital trauma care have also been reported in a previous study [50, 51]. Further research is needed to investigate the influence of EMPs on the performance of trauma care system and outcome of trauma patients in the country.

5.3 UTILIZATION OF TRAUMA CARE AND INFLUENTIAL FACTORS

Study IV showed that the hospital resource utilization associated with RTIs in Iran was substantial, and that it varied by age, gender, socio-economic status, injury characteristics and health outcome of the patients.

Based on the findings, although the average hospital charges in this study were lower compared to reports from HICs [65, 66, 93-95], nevertheless, considering the increased number of RTIs and deaths in Iran, RTIs impose a huge economic burden on Iranian

society. Annual costs of RTIs on the country' economy are estimated to be approximately 2% of GNP [25, 43].

Consistent with previous knowledge [8, 33, 71, 96], RTI victims admitted to the hospitals in this study were predominantly male (male-female ratio 3.4), mainly in productive age and from lower socioeconomic groups (both in terms of education and occupation). Moreover, vulnerable road users such as pedestrians and motorcyclists consisted of the majority of the patients. These two groups mainly included from people with lower socio-economic backgrounds [10].

The findings showed that hospital resource utilization varied with age, gender, socio-economic status (education and occupation), injury characteristics (injury severity and road user types) and health outcome of the patients. Studies in other countries (all conducted in HICs) have reported similar results indicating that factors such as age, gender, injury severity, hospital mortality and insurance type as predictors of hospital resource utilization for injuries [65, 66, 93, 95, 97]. Moreover, previous studies have shown that not wearing a safety helmet or seat belt is associated with higher hospital resource utilization [98-101], but in the current study although patients, who did not use safety helmets stayed longer in hospital and had higher hospital charges, the numbers were too small to attain statistical significance.

An important finding of the study was the low coverage of health insurances (more than half of the patients did not have any type of health insurance) and the positive effect of having insurance on hospital resource utilization. The findings support the conclusion that lack of health insurance coverage could be a barrier limiting access to and utilization of hospital care. Insurance status has also shown to be an important factor influencing utilization of health care services in general in Iran [49]. In 2008 a new law was approved in Iran, which meant that all hospital care for RTI victims became free of charge. Further studies are needed to investigate the effect of the new law on utilization of hospital care among RTI victims.

5.4 METHODOLOGICAL CONSIDERATION

The studies in this thesis are based on several data sources utilizing a combination of methods, both quantitative and qualitative. Studies I and IV are cross-sectional studies using national databases and Studies II and III are qualitative studies using a Grounded Theory approach.

In this section, consideration regarding the design and methods of the studies and weaknesses of the main data bases used in Studies I and IV will be discussed.

5.4.1 Ecological design

Analysis of the distribution of pre-hospital trauma care resources in Study I should be considered within limitations of an ecological study design (known as ecological fallacy or bias). An ecological study focuses on the comparison of groups, rather than individuals; thus, individual-level data are missing on the joint distribution of variables within groups. Variables in an ecologic analysis may be aggregate measures, environmental measures, or global measures [102]. Study I comprised aggregated data at the province level. This implies that the variation within provinces may be higher than the variation between provinces. Therefore, these results are not necessarily applicable to smaller geographical units such as counties or cities. However, some studies argue that using larger geographical units provide more reliable estimates than smaller units [103, 104].

5.4.2 Qualitative approach

Qualitative research needs to be evaluated in terms of the trustworthiness of its findings. In qualitative research four issues of trustworthiness usually demand attention: credibility, transferability, dependability, and confirmability [105, 106].

Credibility, corresponding to internal validity, refers to confidence in how well the data collection and the analysis process address the research objective [107]., In order to ensure credibility, in Studies II and III we employed a combination of different methods including constant comparison, member check, peer debriefing and triangulation. *Constant comparison* was done by returning to the data several times during the analysis to verify and develop categories and concepts [63, 108]. For *member checking* some of the participants were contacted after the analysis and were given a summary of the primary results to discuss whether the results were in accordance with their perception of the interviews. As a further validity check, some parts of all the transcripts and the preliminary sets of codes and categories were checked by two experts in qualitative method within the research team (*Peer debriefing*). Moreover, *triangulation* of researchers with different background, from Iran and Sweden, in the research team helped to take into account different perspectives when analyzing the data.

Dependability, corresponding to reliability, encourages researchers to provide an audit trail (the documentation of data, methods and decisions about the research) which can be laid open to external scrutiny [106]. Audio recordings and transcripts of the interviews conducted in Studies II and III are available. Moreover, considering the fact that in the grounded theory collection of data and the analysis go on simultaneously, this in itself supports dependability and enhances flexibility [105].

Transferability or generalisability refers to the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings [107]. Here, the aim is to give readers enough information (about the context of the study) for them to

judge the applicability of the findings to other settings [106]. In Study II and III, the contexts of the studies were described in such a way that the readers could judge to what extent the findings are applicable to other settings within Iran or other countries.

Confirmability in qualitative research corresponds to objectivity in quantitative designs. Confirmability means that the evaluation of the neutrality of a research project is moved from the researcher as a subject, and instead is focused on the data and the interpretation of the data [105]. Conducting peer debriefing and also triangulation of researchers in the research team help to ensure confirmability.

5.4.3 Limitations of the data sources in studies I and IV

Forensic Medicine Organization (FMO): In Study I, data concerning traffic-related deaths and injuries was obtained from the FMO. This organization is the only data source that covers information regarding road traffic-related deaths and injuries for all provinces in Iran. Although FMO is considered as the most reliable source of mortality data in Iran [26, 58] it has been indicated that the numbers of missing cases are higher in rural areas. This means that traffic-related deaths and injuries may have been underestimated in rural provinces.

Iranian National Trauma Registry Database (INTRD): This database that is the largest trauma registry database in Iran has some limitations that may affect the findings of Study IV. First, the database is hospital-based and might not be representative of the pattern of RTI in general. Second, the database excluded the patients who stayed at the hospital less than 24 hours. These patients may have received care at the ED and have been discharged or died in the ED (or before reaching the hospital) because of the severity of their injuries. Excluding these patients from the database may affect the results of the study by underestimating hospital resource utilization (LOS and hospital charges) and in general the burden of RTI.

Third, total hospital charges in the database are billed charges and do not reflect actual payments nor true hospital costs. Therefore the true hospital costs of RTIs are likely to be underestimated in Study IV.

Fourth, information such as pre-hospital transportation time and use of safety equipment (safety helmet/seat belt) are self-reported. Therefore these two variables could be over-estimated, the first one because of recall bias and the second one based on false claims (to avoid legal consequences). Moreover, in cases when the patient was too ill to report this information, it was supplied by the accompanying person, which may have led to misreporting.

5.4.4 Other considerations

In Study I, only facilities or resources (ambulance, dispatch sites and staff) belonging to the EMS were included in the study. In some situations, especially in crashes in small cities and multiple crashes, other organizations (beside EMS) like the Red Cross, the Army and even some hospitals usually send ambulances and medical rescue teams to the crash sites to help the victims. The extent to which these organizations participated in the transportation of victims to hospitals or provided medical care was not available at the time of conducting this study.

In Study II, one potential limitation is that the data collection was done by two different interviewers and at two points in time. However, this could also be seen as strength of the study since both interviewers were involved in the whole process of conducting the study. Furthermore, Study II focused on experiences and perceptions of staff and professionals working in the EMS and do not reflect the views of other personnel involved in post-crash management such as the police, firefighters and the Red Crescent.

In Study IV, we had no possibility to adjust total hospital charges based on the consumer price index for healthcare due to substantial (monthly and annual) fluctuations in the index in Iran. Therefore, the estimated hospital charges may not provide an accurate reflection of the total charges associated with RTIs, although we have no reason to believe that this has affected the predictors of total charges.

6 CONCLUSION

The thesis aimed to explore factors influencing access, provision and utilization of trauma care for road traffic injuries in Iran. The thesis assessed access to pre-hospital trauma care facilities for RTIs across the country. In addition, health professionals' and injured patients' perception and experiences regarding provision of trauma care were explored. Finally, hospital resource utilization by RTI victims and influential factors were analysed. The main conclusions related to the thesis are listed as following:

- The pre-hospital trauma care resources were not distributed based on traffic-related mortality and morbidity (I).
- There was an unequal distribution of pre-hospital trauma care resources among provinces (I).
- Lack of interaction and common understanding of the role of the EMS between different actors involved in pre-hospital care emerged as key issues that contributed to an ineffective pre-hospital trauma care system (II).
- Lack of a systematic approach for providing trauma care was the main barrier to effective provision of trauma care at the emergency departments (III).
- The hospital resource burden by RTI victims in Iran was substantial and varied by age, gender, socio-economic status, injury characteristics and health outcome of the patients (IV).
- The majority of the RTI victims admitted to the hospitals were not insured and these patients had lower hospital resource utilization than insured patients (IV).

7 POLICY AND RESEARCH IMPLICATIONS

On the basis of our findings there are some areas that need to be considered by policy makers and researchers in Iran:

- Establishing an integrated trauma care system is necessary in order to regulate provision of trauma care at all levels of care (especially pre-hospital and hospital trauma care) and to coordinate all involved actors in providing trauma care.
- Implementing evidence-based improvements such as establishing trauma teams, trauma training courses for staff working at EMS and the EDs on a regular basis, and training of laypeople in first aid. These interventions should be modified based on the context of Iran before implementation.
- A need assessment of hospitals and other health facilities, based on available guidelines such as “WHO Guideline for Essential Trauma Care”, is necessary in order to identify their capabilities for providing trauma care. This assessment can be used as a basis for designation of trauma centres in the country.
- Considering the substantial improvements that have been made regarding pre-hospital trauma care facilities in Iran during recent years, there is a need for further research to investigate if the accessibility (in terms of distribution of resources), utilization of ambulance and pre-hospital care and pre-hospital transportation time has improved.
- Further research is needed to explore the trauma care system from the perspective of policy makers in the Ministry of Health and other stakeholders
- Further research needs to assess the impact of Emergency Medicine specialists on the trauma care system and the outcome of trauma patients in the country.
- Further studies are needed to investigate the effect of the law “free of charge hospital care for RTI victims” on hospital resource utilization and quality of care among RTI victims and also the effect of insurance on other types of traumas.

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